SIMULATION AND
COMPUTER DIRECTORATE
(SIMCOM)

HISTORY OF ACTIVITIES

1967-1969

INDUSTRIAL COLLEGE
OF THE ARMED FORCES

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FOREWORD

It is important for any organization, no matter what its purpose, to take stock periodically of where it is, where it has been, and whether it is tending. This need is particularly acute for an organization operating in a field which is expanding and changing as rapidly as simulation and computers.

This manual records the history of activities of ICAF's newest directorate, the Simulation and Computer Directorate (SIMCOM). The manual is divided into three distinct sections. The first section recounts the circumstances that occasioned the establishment of SIMCOM and describes the Directorate's first year of activities (1967-1968). The second section is devoted to a discussion of the use of computer time-sharing in educational simulation with special reference to ICAF's experience. The final section of the manual documents SIMCOM's activities during this past academic year (1968-1969).

The description of activities contained in the manual should provide useful background and guidance for the Directorate. Moreover, it will facilitate the sharing of ICAF's experience with other schools and institutions interested or involved in simulation and computer activities.

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HISTORY OF ACTIVITIES OF THE

SIMULATION AND COMPUTER DIRECTORATE

1967 - 1968

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SIMULATION AND COMPUTERS

1. GENERAL

As early as 1961, the Industrial College recognized that simulation
and automatic data processing were becoming increasingly important tools in
both management training and national security management, itself. In
keeping with these trends, the Industrial College has made increasing use
of these techniques in its programs. The reasons for these innovations are
severalfold: 1) to introduce the ICAF student to the ever more complex
uses of simulation and computer technology, 2) to provide the student with
some firsthand experience with these techniques and thus help dispel the
aura of "mystery" which surrounds simulation and computer methods, and
3) to ˈˈment other methods of instruction through student involvement
in comp   ˈˈed simulations which dynamically portray relevant course
content.

History of Directorate

Up until 1968 the responsibility for conducting simulations at the
Industrial College rested with the user, viz., the Resident School. The
mission of planning and providing computer support and automated facilities
for the College was assigned to a special officer acquired in 1967 by the
Office of Academic Plans and Research. This officer was later joined by
two civilian computer specialists.

Initial plans had called for establishing a computer center at the
Industrial College. Conservative estimates put the costs of such an in-
house computer facility at $2.5 million for "hardware" alone. This would
have been approximately half of the budget requirements when one accounted
for the ancillary costs associated with the operation, maintenance, and
necessary software. After weighing the relative costs, need for space, and
manpower required against the advantages of being tied into several large,
high-speed computers through remote terminals, it was decided that "time
sharing" was more consonant with ICAF's needs. The advantages of such a time
sharing capability were: 1) savings--it eliminates the necessity for a large
outlay of capital for a computer system which would eventually become obsolete;
2) flexibility--it would allow ICAF to lease time from computer facilities
which could best serve the needs of a particular situation and allow the
College continual access to the most modern equipment; 3) reliability--by
having access to several computer systems, time sharing would assure contin-
uous service during a simulation; e.g., if one system went down, one could
quickly switch to another system; 4) programming languages--with access to
several systems having different language capabilities, one may make use of
a wide variety of programming languages.

To meet the need for greater simulation expertise, an officer with 9 years experience in simulation and gaming was assigned to AP&R in July 1967. Even with this important addition, the small group of experts in AP&R found it difficult to keep pace with the increasing use of simulation and automation programs at the College. As a result of this and earlier decisions to increase the number and quality of simulations in the Resident School curriculum, a number of outside contract services were required in 1967. Concurrent with these contractural services, three officers in AP&R worked almost exclusively for 3 months to prepare and conduct a new computer-assisted simulation in January 1968. Another officer and one civilian computer specialist devoted sizable portions of their time during this period to the development of computer support for this simulation.

In addition to these activities, the small group in AP&R sought to respond to the Correspondence School's desire to have major parts of its administrative procedures automated. Because these requests taxed its limited capability, the group found it necessary to recruit part-time assistance from officers engaged in other ICAF activities.

As the simulation and computer application workload increased, Academic Plans and Research found it difficult to cope with the additional burden without adversely affecting its primary mission. Hence, the plans for a separate Directorate expressly for simulation and computer applications were accelerated and the Simulation and Computer Directorate (SIMCOM) was established as a distinct entity on 22 January 1968.

The Director of SIMCOM serves as the principal advisor to the Commandant and the Deputy Commandant on the use of simulation and computers and serves as a permanent member of the Faculty Board. His office is responsible for:

    a. Organization and maintenance of comprehensive data files on plans, research, operations, and analysis applicable to simulation and automation in the academic community.

    b. Planning and development of simulation and automation programs for the Industrial College.

    c. Liaison activities with the collegiate community, governmental agencies, other military schools, and private organizations in the field of simulation and automation.

    d. Supervision of all simulation and automation systems used by the College.

    e. Training of faculty members necessary to the conduct of simulations.

    f. Continuous review, research, and analysis of existing and potential simulation models.

(Authority: Organization Manual, Industrial College of the Armed Forces, 1968.)

SIMCOM was established with the following personnel assigned: one military Director (O-6), one Deputy Director (O-6), one senior Computer Specialist (GS-13/14), and one Computer Specialist (GS-12). In addition, two special projects officers and two Navy enlisted women were assigned full-time to SIMCOM, although these persons do not have authorized billets at ICAF. Two Navy officers with other billets at ICAF have worked with SIMCOM, one part-time and the other almost full-time. Official requests have been made for more adequate authorized manning of the new Directorate.

II. COMPUTER APPLICATIONS

One year ago, the Industrial College installed its first remote teletype terminal. Today it has six remote consoles, one of which is totally portable. These terminals provide access to the several time sharing systems currently being used by the College. One is located at the Missile and Space Division of the General Electric Company at Valley Forge, Pennsylvania. The computers used by ICAF there are the GE 265, GE 605, and the GE 635. Another system is located at the U.S. Air Force Rome Air Development Center (RADC) in Rome, New York. At RADC there is a GE 635, and there will soon be a GE 645. In addition ICAF uses the General Electric facility at Bethesda, Maryland, to debug programs and for training purposes. During the World Politics Simulation in January 1968, the College also made use of a standby system at the Aero Space Defense Group in Syracuse, New York. The CDC 6400 computer system at Temple University, in Philadelphia, is also being used for program testing and provides yet another backup system when needed. ICAF also uses the GE 255 time-sharing system located at the U.S. Military Academy, West Point, New York. Through these systems ICAF can make use of no less than five programming languages; namely, BASIC, FORTRAN, COBOL, JOVIAL, and TINT.

The use of multiple time-shared computer centers has provided ICAF with great versatility at a very low cost. The systems accessible to ICAF exceed $25 million in total value and provide the College with service reliability through redundancy. Had ICAF installed its own computer at a hardware cost of $2.5 million, reliability and versatility would have been less than half that of the present time-shared system, the cost of which is less than $50,000 per year-- about 50 times less than a modest computer center as planned.

Through May 1968, jobs requiring batch processing and high speed printouts have had to be processed at local computer centers and hand carried to the College. This did not present a major problem as long as the complexity of simulations and data analysis at ICAF did not require high speed printouts with short return times. However, the high volume printout requirements of the new simulations planned for the curriculum have justified the acquisition of a high-speed data terminal which will allow remote batch-processing and will produce printouts at about 15-20 times the speed of the teletypewriters currently used. The additional cost for this new console has been balanced by the primary use of the RADC system (lower costs) with the commercial centers used as back-up systems.

In addition to the hardware described above, ICAF has acquired an IBM Keypunch Machine to assist in the automation of the correspondence files in the Correspondence School and to prepare batch processing jobs as they are required throughout the College.

Support of the Resident School

In addition to providing computer support for the simulations used in the Resident curriculum as discussed below, SIMCOM has provided computer support for the Resident Courses in Automatic Data Processing and Scientific Decision-making. Working with AP&R, SIMCOM has sought to develop an automated system for processing student background questionnaires using optical scanning equipment. The information on each student is stored and may be selectively recalled through a specially designed information retrieval system. Efforts are now underway to automate major portions of the Resident School's administrative procedures; viz., student group assignments and student office assignments. Of course, SIMCOM provides assistance and advice to both the students and faculty of the Resident School on matters related to computer applications, to include student research projects, course development, and student-faculty training.

SIMCOM is currently exploring the feasibility of providing the Resident School with computer-aided instruction (CAI), particularly in the areas of computer programming (BASIC and FORTRAN) and math refresher courses. CAI can offer ICAF a number of advantages. Firstly, it provides individualized instruction in the sense that a student can tailor his instruction to his own needs and progress at his own rate. This is particularly important given the highly varied backgrounds of the entering ICAF students. Secondly, it relieves the faculty of the burden of having to provide instruction in areas where they may have limited competence and frees the limited number of faculty members who are qualified in an area to concentrate on more advanced instruction. Thirdly, it gives the student considerable "hands-on" experience with a computer system. At present, it would appear that ICAF will be able to offer CAI's in at least computer programming as early as August 1968. Eventually, it is hoped that ICAF can develop a fairly extensive library of computer-aided instruction which, of course, will be a boon not only to ICAF but to all senior military schools who may want to take advantage of it.

Support for the Seminar School

With the acquisition of a Vernitron Dataport (a portable remote teletype terminal), SIMCOM now provides the Seminar School with the capability of demonstrating ICAF's time sharing computer system on their road trips. The terminal may be linked to any of the computer facilities to which ICAF has access and requires only a standard telephone and 110 v. electrical outlet. A staff officer from the Seminar School has been trained to use the equipment and is thoroughly familiar with the extensive capabilities it makes available.

Support for the Correspondence School

An elaborate processing system developed for use at Fort Benning is being adapted for the Correspondence School. When operational, this system will automatically perform a wide variety of the administrative tasks required in the Correspondence School. The system will perform record-finding functions, inventory control, test grading and recording, and will generate a variety of report statistics. SIMCOM is also in the process of developing an automatic labelling system for use by the Correspondence School in handling its high volume of outgoing mail.

Support for Academic Plans and Research

With the development of a remote batch processing capability, SIMCOM can provide full computer support for the research and planning activitites of AP&R. This in-house capability will allow for much more rapid processing of student critique cards and will provide the opportunity for much more elaborate analysis to be conducted. It is also anticipated that AP&R will make extensive use of the student background information retrieval system now being developed. With the increased computer capabilities provided through SIMCOM, it is likely that AP&R will make much more extensive use of computer processing in its course scheduling, evaluation, and planning. Tentative plans are now being drawn up for the automation of course histories and curriculum information. This information would be constantly updated and could be selectively retrieved upon request. By providing a library of statistical programs, SIMCOM will further supplement and enhance the research and analysis capabilities of AP&R. Of course, SIMCOM also provides advice and consultation to AP&R in data processing and computer applications.

Support of SIMCOM

In addition to providing support for the other directorates at ICAF, the computer capabilities available through SIMCOM play a vital role in its own internal operations. They allow for the in-house development, adaptation, and/or modification of simulations and provide the analytic capabilities necessary for the evaluation of simulation exercises. The Directorate also anticipates the use of automated procedures in fulfilling its responsibility to develop and maintain comprehensive bibliographic and data files on plans, research, operations, and analysis applicable to simulation and automation in the academic community, governmental agencies, other military schools, and private organizations.

III. SIMULATION

This year's ICAF curriculum contained three simulation exercises participated in by the entire student body. A pilot run of a fourth simulation was also conducted with a small group of students during the last major exercise.

All of these simulations are designed to supplement and enhance student learning within the particular blocks of instruction during which they are conducted. These simulations serve to summarize and integrate relevant course content. By dynamically protraying salient features of the real world in condensed time, they provide the ICAF student with a synthetic but realistic environment within which he can practice decisionmaking and learn management skills. Because of the novel nature of the educational vehicle, these exercises tend to produce high student involvement and motivation and to relieve the tedium often associated with more conventional techniques. A residual benefit arising from all of ICAF's simulation exercises is increased student familiarity with simulation methods, their strength and weaknesses.

Simulation in the 1967-68 Curriculum

One of the three simulations that were an integral part of the 1967-68 ICAF core curriculum was conducted during each of the three major blocks of instruction. The first, the IBM Business Decision Game, was run in the fall as part of Course B, The Management of National Resources. During this game, the ICAF students were given an opportunity to "put into practice" many of the lessons they had learned regarding the problems of management decision-making. Operating in an environment which highlighted and summarized important aspects of their previous instruction; e.g., marketing, R.&D., and production in a competitive environment, the students confronted and acted upon typical problems faced by business managers.

The second simulation exercise was conducted in January as part of Course C, The Management of National Security. This was an international relations simulation called the World Politics Simulation (WPS). The original model was designed by Dr. William Coplin of Wayne State University and had been used by the State Department's Foreign Service Institute. A specially adapted version of the model was developed for use at ICAF in consultation with Dr. Coplin. This simulation was designed to place ICAF students in an environment similar to that in which foreign policy decisionmakers operate. By placing the students in the roles of national and international decision-makers, the simulation sought to foster a fuller appreciation of the problems and complexities of international relations and show the intricate linkage between the internal and external affairs of nations.

The third simulation used in the ICAF curriculum was the Technological, Economic, Military, and Political Evaluation Routine (TEMPER). TEMPER was originally developed by the Raytheon Company for JWGA and was modified for use at ICAF in 1965-66. This simulation was used in Course D, The Management of the Department of Defense, near the end of the year. It sought to reinforce the students understanding of the interplay of military, economic, political, and psychological factors in national decisionmaking and to provide something of a review of the entire curriculum by bringing together many facets of the core and horizontal courses.

In addition to the above, a pilot run of another simulation, the Defense Management Simulation (DMS), was conducted with a small group of students and was run concurrently with TEMPER. This simulation was developed by Peat, Marwick, and Livingston under the name of Program Management Simulation Exercise (PMSE) for use at the Defense Weapons Systems Management Center (DWSC). The pilot run of DMS was the final phase of a research project undertaken by a student committee organized to investigate and evaluate the DMS model for possible inclusion in the ICAF curriculum. The simulation incorporates many significant features of current DOD management practices emphasized in the ICAF curriculum. It provides insights into the problems of program management and offers a vehicle for practical familiarization with the sort of analytical techniques which are employed in all areas of defense management. On the basis of the DMS Student Committee report and independent evaluation by staff and faculty, DMS will become a part of next year's course on Management in the Department of Defense.

The following summarizes the objectives and relative complexity of the four simulations conducted at ICAF this past year:

I. IBM Game

OBJECTIVES

1. To provide students with the opportunity to apply some of the management principles to decisionmaking and create an appreciation for the major problems involved in conducting a business in a competitive environment.

2. To provide a group environment in which objectives are set, policies are established and data is analyzed as a part of a decision process in attaining objectives.

3. To provide some appreciation for the computer as a tool in decisionmaking and simulation.

4. To generate involvement and a potential for new insights to a larger degree than in other methods of education.

COMPLEXITY

The IBM simulation is modestly complex employing a program of approximately 1,500 computer instructions. There are 12 decision points per cycle, and the exercise is usually run through 9 cycles. A total of 10 academic periods is used for the simulation.

II. WPS Game World Politics Simulation

OBJECTIVES

1. Foster an understanding and appreciation of some of the problems and pressures in the processes of national and international decisionmaking.

2. Promote the development of decisionmaking skills by allowing students to develop and execute strategies in a world environment.

3. Enhance knowledge of the complex interaction and interdependence of national and international affairs.

4. Aid the educational process through involvement and motivation and provide an environment for new insights.

5. Provide a better understanding of simulation methods, their strength and weaknesses.

COMPLEXITY

WPS II is a computer-assisted simulation and is relatively easy to understand. The automated portions consist of four main programs containing a total of about 1,300 FORTRAN statements. These programs operate from a data base some 7,000 words. The exercise as used in January required seven academic periods and was conducted during 2 consecutive days. There are a variable number of decision points per period, usually ranging between 30 and 40. A game consists of three to five periods.

III. TEMPER Technological, Economic, Military and Political Evaluation Routine

OBJECTIVES

1. To provide a summarizing exercise which generates enthusiasm and involvement thereby enhancing the educational process.

2. To simulate the day-to-day interactions of the significant nations of the world, emphasizing their political, economic, psychological, and military behavior in their defense environment.

3. To provide the students with a better understanding of the practical use of complex simulations as analytical tools for the decisionmaker, and eliminate the apprehension of their use.

COMPLEXITY

TEMPER is considered complex. It has slightly over 13,000 computer instructions and uses 12 tape drives on which information is stored and used to support overlays required by insufficient core size. There are two main computer programs and 56 subroutines which make use of 198 constants, 854 parameters and as many as 8,048 variables. The number of decisions per period can vary, depending on the game design, but usually number between 40 and 50 in the ICAF version of TEMPER. Man/machine interchange periods are preplanned and usually number three, (2 years, 3 years, and 4 years game time).

IV. DMS Defense Management Simulation

OBJECTIVES

1. To provide an environment in which the students may apply and test their knowledge and skill in decisionmaking as it relates to the life-cycle of a weapon system.

2. To improve motivation and involvement which enhances the educational process and makes possible deeper insights regarding weapon system management problems.

3. To create an environment requiring weapon system management decisions in a few hours which normally would span many years in actual experience.

COMPLEXITY

DMS uses three tape drives to execute a program containing approximately 3,500 FORTRAN statements. The program operates from a data base of 15,000 words. The simulation has six "decision points", five of which are man/machine interchange points. The number of major decisions at each junctuure from point to point, ranging from 3 to 15. The simulation as used now at DWSMC takes 28 hours playing time.

Other Simulations

While the above simulations were the only simulations actually conducted at ICAF this past year, SIMCOM is responsible for constantly reviewing developments in the field of simulation and computers with an eye toward improving and/or enhancing the quality of ICAF simulation offerings. Consonant with this, SIMCOM is currently investigating several simulations which are potential candidates for inclusion in the curriculum either as additions to, or substitutes for, current simulations.

Among the most promising of these is the Aerospace Business Environment Simulator (ABES) developed by Lockheed for the training of its management personnel. This simulation places students in the executive decision roles of a defense related industry and graphically illustrates the problems of operations and planning in a highly competitive industrial environment; e.g., contract availability, contract bidding, labor management, cost control, and R & D. ABES is a fairly complex simulation which would be an excellent complement to or substitute for the current IBM game in the ICAF course on The Management of National Resources.

Another promising candidate in the area of business and industrial management is the Wharton Game developed by the Wharton School of Finance and Commerce. Like ABES, it is considerably more complex than the IBM game. Participants operate in a competitive environment and make decisions regarding production, inventory, plant expansion, product and process improvement, manpower, marketing, and finance.

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Preliminary investigation is just now underway on yet another simulation of a business variety but which is international rather than national in orientation. It is the International Operations Simulation (INTOP) designed for the Graduate School of Business, University of Chicago. INTOP illustrates the management problems in overseas operations and in coping with overseas-based competitors in domestic markets. With the increasing significance of international operations and competition from abroad, the lessons to be gained from INTOP might well prove to be a valuable addition to the ICAF curriculum.

Dromedary is yet another simulation that is being considered for use in the ICAF curriculum. This simulation has already undergone preliminary investigation, and the College already has access to two operational versions of the simulation through its time sharing computer systems. This simulation was originally developed by the RAND corporation for use in a classified aircraft study and is currently used as the basis for a course in system analysis at the U.S. Military Academy. Dromedary is an excellent vehicle for illustrating both the problems of systems analysis, cost-performance-effectiveness and sensitivity analysis and the problems of simulation and model construction. Since the Industrial College has become increasingly interested in familiarizing its students with all of these problems, it is thought that Dromedary may be a valuable addition to the current instruction on scientific decisionmaking and quantitative analysis.

One of the continuing objectives of SIMCOM is to provide the College with as broad and as flexible a simulation program as possible. Pursuant to this, SIMCOM seeks to develop a library of simulations which are fully operational through ICAF's in-house computer system and which will be available for use at ICAF in either regular or refresher instruction.

Analysis and Development

SIMCOM's responsibilities do not, of course, cease once a simulation is incorporated into the curriculum. Firstly, it seeks to improve and refine the models and procedures used in the current simulation exercises. This involves a program of fairly detailed and systematic analysis and evaluation of all ICAF simulations. Secondly, SIMCOM monitors new developments in the field of simulation which might be added to or substituted for existing programs and which promise to enhance the quality of the ICAF curriculum.

Both the in-house analysis and development of simulation models and the monitoring of outside activities by SIMCOM feed into another long term objective of the Directorate; namely, to develop a year-end summarizing simulation (YES) for the ICAF course. There is evidence of a real need to in some way capture the waning interest and enthusiasm of students as their year at ICAF draws to a close and to highlight, summarize, and integrate the salient aspects of the instruction they have received. An appropriately designed year-end simulation exercise would seem to be the answer. SIMCOM is presently investigating the possibilities of developing such a simulation.

It is thought that the TEMPER simulation may provide some of the elements from which the YES simulation might be developed in a modular way. The feasibility of this approach is the subject of an on-going contract study by the Computer Command and Control Company.

Residual Benefits to other Military Schools

While SIMCOM's efforts are directed to the support of the other ICAF Directorates, these efforts also provide the basis for cooperation with and assistance to other military schools. The development and realization of simulations at ICAF relieve other military schools of the necessity of retracing its efforts. Because all of ICAF simulations are thoroughly documented, they are readily available for use by other schools. Likewise, SIMCOM's experience with the development of ICAF's time sharing computer capabilities provides the basis for potentially valuable advice to other military schools interested in developing some kind of computer capability.

SECTION II

CURRENT AND FUTURE USES OF TIME-SHARING

IN EDUCATIONAL SIMULATION

BY

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CURRENT AND FUTURE USES OF TIME-SHARING IN EDUCATIONAL SIMULATION

THE NEED FOR NEW TOOLS IN MANAGEMENT

Although it has become almost trite to state that technology is increasing at a phenomenal rate, the reality of that fact is unchallenged and presents today's managers with almost insurmountable tasks in evaluating the volume of relevant data available in most problem situations. In addition, managers, both public and military, find themselves struggling with advanced scientific concepts and changing technologies. Computers, a product of this new technology, can and are being used to assist in the evaluation of vast quantities of data and to enhance the decisionmaking process.

At the Industrial College of the Armed Forces (ICAF), one of two post-graduate institutions under the aegis of the Joint Chiefs of Staff,[1] it has been decided that there is a place in the educational process for simulation and the computer. During the past year, ICAF organized a new Directorate for Simulation and Computers (SIMCOM), which has adapted new educational methods to ICAF's ten-month curriculum. These innovations include simulation, computer-assisted instruction, time-sharing terminals, and remote consoles. An integral part of these is the requisite software (programs which operate the computers).

A prime factor in the adaption of such innovations was student diversity, one of the greatest challenges at ICAF. Take a top-flight engineer with no training in political science, a skilled personnel officer with only a superficial knowledge of automatic data processing, a Phi Beta Kappa intelligence officer who never had a course in economics, an outstanding legal administrator with no background in modern management procedures, a former test pilot now in a key planning position who never completed his undergraduate work. Add 175 other selected military officers and civilian Government executives with skills and background just as disparate, and you have a typical resident class at the Industrial College. These students are enrolled at ICAF to learn how to manage the country's resources for national security. To help the ICAF faculty meet the student's diversified needs, simulation and time-sharing ADPS (Automatic Data Processing System(s)) were instituted.

DEFINITION OF TERMS FREQUENTLY MISUNDERSTOOD

In order to decrease semantic difficulties, it is always appropriate to define terms. There are three fundamental terms which deserve mutual

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[1]The JCS administers the National War College (NWC) and ICAF. Both are located at Fort McNair, Washington, D. c.

understanding prior to discussing simulation: model, game, and simulation. In defining these and other terms, the approach will be pragmatic—not to force the reader into the mold of the author, but rather to create an environment for common understanding.

In the context of common understanding, this paper will discuss the why, how, and what of simulation in education, as well as some of the advantages and limitations in the development and use of simulation. Particular emphasis will be placed on the use of simulation in a time-shared environment, again stressing some of the advantages and limitations of such a system.

The first term frequently misunderstood during discussions on simulation is "model". Most of us work with models every day, frequently unaware of the fact that we are doing so. There are three general types of models: two-dimensional, three-dimensional, and descriptive. The last one may be divided into two kinds, mathematical and verbal. A very general definition of a model is: THE STATIC REPRESENTATION OF RELEVANT REALITY.[2]

"Static" is a key word in this definition. It is necessary for a model to "stand still" long enough to be described whether that description be two-dimensional, three-dimensional, mathematical, or verbal. In other words, the "state"[3] of reality at any given time lends itself to being modeled.

Examples of two-dimensional "state" or static representations of relevant reality are maps, blue prints, and pictures. Common examples of three-dimensional static representations of reality are mock-ups, wind-tunnel aerodynamic shapes, automobiles, trains, pipelines, and buildings. These may be constructed on almost any scale desired by the user. Einstein's equation for energy ($E=MC^2$) is an example of a mathematical model. Scenarios which describe the opening setting for a "cold war game" are examples of verbally described models.

The three-dimensional model suggests another key word in this definition of model. That word is "relevant". The engineer who places a model airplane in a wind tunnel is not interested in the bombardment system or the communications gear to be associated with the end product;

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[2]Colonel William Thane Minor, Simulation Briefing, ICAF, October 1968.

[3]For excellent discussion on the "State" of models see Simulation Using Digital Computers by Evans, Wallace & Sutherland, Prentice/Hall Inc., Englewood Cliffs, N.J., 1967.

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they are not relevant to his problem. He is therefore not likely to place scaled versions of radios or bombing devices in his aerodynamic model.

During the past decade, "war game" has become a very popular term, with almost as many meanings as users. It has been used this month by the news media to describe current NATO exercises. It is frequently used to describe highly detailed analyses which use operations research and system analysis techniques for complex target selection, penetration tactics, and damage assessment. The term "war game" is also applied to structured efforts involving teams of individuals "brainstorming" a common problem from different perspectives. None of these "meanings" is technically incorrect. A definition which can satisfy all "types" of war games, however, is:

THE PURPOSEFUL DYNAMIC REPRESENTATION OF THE RELEVANT SEGMENTS OR AGGREGATES, SOMETIMES BOTH, OF MILITARY REALITY IN AN ENVIRONMENT OF LESS THAN PERFECT INFORMATION.[4]

This definition becomes applicable to other types of games through the substitution of an appropriate designator for the word "military"; e.g., business (games), industry, international affairs, urban expansion, economic, diplomacy, etc.

Several key words in the definition are: purposeful, dynamic, relevant, segments, aggregates, and imperfect information.

For a game of any type to be effective, there must be an objective, or reason, for examining a representation of reality. Therefore, the game must have a specific aim--be purposeful.

A game is dynamic in that it represents change over a period of time. As hypothetical events occur, decisions are made and variables change. The "state" of the model, at cycle points of game time, may be examined. One of the assets of gaming, in fact, is the ability to examine "slices" of reality in a "changing" environment.

The very fact that one examines factors in a fictitious environment instead of waiting on the real world makes it important that only the relevancies of that which is under examination be included in the gaming environment. Managing data and manipulating it in meaningful ways is difficult at best. It is, therefore, most important to include in the game only those factors which are preceived as relevant to the situation--the goals and the perspective of the gaming environment.

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[4]Colonel William Thane Minor, Simulation Briefing, ICAF, October 1968.

Portions of a game may include representative segments of reality while other portions may use aggregation. For example, in a simulated global strategic nuclear exchange, every sortie in a strike plan may be included while the reliability of the aircraft which represents that sortie may be an aggregation of data collected from thousands of sorties flown by aircraft of that specific type--or it may be the aggregation of all the assumed, or calculated, mean-time-to-failure rates for all the systems which make that aircraft operational.

In all games, each team has less-than-perfect intelligence about its opponents. Moreover, this is true even in a "one-sided" game where one may test many theories concerning the "what if" capabilities of a theoretical enemy (opponent).

At the Industrial College, the term "simulation" is used rather than "game". This is primarily because "war" is bad and "games" are sometimes thought of as frivolous. While all war games are simulations, not all simulations are (war) games. Therefore, simulation may be defined as THE PURPOSEFUL DYNAMIC REPRESENTATION OF RELEVANT REALITY.[5]

WHY SIMULATION?

It is logical to discuss the "why" of simulation before discussing the "how", since the reasons for simulation usually dictate the methods used. There are four primary reasons why simulation can be useful: economy, research, education, and management.

Economy of time, risk, manpower and dollars are key factors which may make simulation useful. In the real world, it may be costly, or even impossible, to wait for feedback resulting from required decisions or for the results from suggested contingencies or selectable alternatives. In simulations, one may develop synthetic circumstances in which decisions relating to contingencies or alternatives may be tested with resulting feedback, over very short periods of time—in other words, the exploring of "what if's".

Decreasing risk, particularly where safety of people and property is concerned, has been a function of simulation for many years. The old Link Trainer is a very good example; it's much safer to "dive" a Link Trainer into the "ground" than it is to misread the altimeter during a descent under actual instrument conditions in a real airplane. Since war is too dangerous to fight, the war game type of simulation takes on extremely important significance, and, without doubt, has made invaluable contributions to the peace of this nation...notwithstanding a minority of current opinions to the contrary.

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[5]Ibid.

The economy of manpower is apparent in simulations where one individual may represent a group, an organization or a political entity or where a small group of individuals may represent an entire nation.

Simulations which describe the 'state' or changing 'states' of reality whether two-dimensional, three-dimensional, verbal or mathematical usually cost fewer dollars than programs operating within reality for the same purpose.

In the area of research, simulation has made significant contributions not as research per se, but as one of the tools of research. For example, insights into problems not previously foreseen have resulted from war games, thus contributing both to the research process and to national security. Among these contributions are: air and ground alert, dispersal, hardening, mobility, timely actions on logistic support, manpower requirements, political and diplomatic actions, and many others.

The third area, education, is one of the most important reasons for ICAF's interest in simulation. Education is perceived as a triad of teaching, training, and learning. The last of these descriptors, learning, is the one receiving major emphasis at the Industrial College. SIMCOM, through simulations used in the curriculum, has provided a unique environment which includes competition, problem immersion, decisionmaking, and rapid feedback. Such an environment produces involvement, interest, motivation, innovation, and creativity. With the environment and resultant behavior described, the end result for the participant (learner) should be easier, more rapid learning (sometimes both), lasting impressions, less rigid thinking, the ability to develop plans/strategy, and improved organizational ability.

Several organizations and scholars[6] have shown that simulation methods in education teach content as well as the best pedagogical methods; moreover, they produce involvement and motivation to a higher degree than anyother educational method.

The fourth area in which simulation has shown promise as a tool is that of management. Decisionmaking is not only the prerogative of management; it is a responsibility. For the manager, simulation can provide useful insights into planning, proposed actions, contingencies, and alternatives, as well as providing a testing environment. While simulation can assist in decisionmaking, however, it should never be considered 'the decisionmaker'.

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[6]Snyder, Guetzkow, Herman, Coleman, Targ and The Foreign Policy Association of New York, among others.

Neither should simulations be considered competitive with scholarly studies; the two should complement each other. Frequently, one will cause the manager to realize he needs the other. For example, many simulations have pointedly shown the need for better study and research in a specific area. Conversely, many studies have dictated a need to provide a simulated environment in which different courses of action can be investigated.

THE "HOW" OF SIMULATION - THE EVOLUTION OF WAR GAMING

From Sun Tzu's "The Art of War" (400 B.C.) to Weikhmann's "King's Game" (1644) is approximately 2,000 years. During that period, the Chinese (perhaps) and the Indic Civilizations (certainly) gave to the world a "game", later to be called "chess".[7] Approximately 200 years later, the Prussian Von Reisswitzes (father and son) originated the "Kriegspiel" which led in 1879 to the publication of the first American Kriegspiel, by Livermore. Until the 1930's, few other significant contributions were made to modern war gaming techniques.

In the last four decades, however, three significant factors have provided the fundamental capability to perform meaningful simulation in education. They are Von Neuman's game theory,[8] the introduction of operations research, and the evolution of digital computers.

As war games have developed over the centuries, they have been of two general classifications, rigid and free. The rigid games have been highly formalized, usually mathematical, while the free games have been of the judgmental type where teams, or individuals, have made the decisions which indicated the 'flow' of the game. It is this writer's judgment that a combination of formalized and judgmental inputs during the simulation provide the most effective learning environment.

THE USERS OF SIMULATION

It was stated earlier that the "why" of simulation must precede the "how" since the goals of simulation have a great influence on the type of simulation used. The three major segments of this nation currently using simulation are industry, government, and education.

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[7]"Chess" is derived from the Sanskrit term "chaturanga" which means "four" (i.e., elephants, horses, chariots, and infantry).

[8]Later revised with the aid of Oskar Morgenstern. (Note: it is recognized that 'game theory' is based on probability theory which, of course, is much older.)

Some of the major industrial users are aerospace, automotive, and utility corporations. Personal visits to some of the largest organizations in these categories[9] indicate use of simulation in mathematical and verbal descriptions (operations research), two dimensions (charting), and three dimensions (scale models and "segments" of production lines).

Users in government include NASA, the armed services, and an increasing number of departments. NASA, without doubt, has the most sophisticated three-dimensional simulators in existence, including spacecraft, such as Apollo, and the lunar module. Moreover, young potential managers are given training at Goddard that includes a management simulation called GREMEX (Goddard Research and Engineering Management Exercise).

All of the armed services use three types of simulations: cold war,[10] limited war and general war. During the past decade, the most used of these have been the general war simulations, which have analyzed the problems of a thermonuclear exchange between major adversaries. In the author's opinion, the most interesting simulations conducted by the armed services are the "cold war" games, which are conducted to surface insights regarding problems of a political, diplomatic, economic, psychological, and military nature in an everyday world environment of "friends", "enemies", and "neutrals". (Note that "cold war" is spelled with lower-case letters, thus denoting total international relations and not the limitations of the so-called US/USSR "rapprochement" in Europe which, more recently, does not appear as much a rapprochement as some had perceived.)

While some government departments have been slow to adapt simulation methods to problem-analysis techniques, new efforts are in the offing. The State Department, for example, is currently experimenting in simulation research with Dr. Shure of System Development Corporation.[11]

In education, the major users of simulation are civilian universities and military institutions. In universities, the widest use is in business schools, psychology departments, and political science/government departments (especially in the field of international relations). The military educational institutions using simulation include the academies, staff schools, war colleges, and the Industrial College.

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[9]Boeing, Lockheed, and Ford; visited during the past 2 years.

[10]Sometimes called "political/military games", "crisis games", "politico-military exercises", etc.

[11]Letter, 17 October 1968, E. Raymond Platig, Director, Office of External Research, Department of State.

THE CHOICE OF SIMULATIONS FOR THE INDUSTRIAL COLLEGE

When ICAF made a decision to enrich its curriculum through the use of simulation and computers, experienced officers in each field were assigned.[12]

With the establishment of SIMCOM, it was determined that similations must complement the curriculum and that they must make use of automatic data processing systems. There are two reasons for the latter policy: 1) the value to ICAF students of learning the strengths and limitations of computers, and 2) the ability of simulation participants to examine more alternatives in decisionmaking when computers assist in the manipulation of data.

SIMULATIONS TO COMPLEMENT THE ICAF CURRICULUM

The ICAF curriculum is divided into three major segments: national resources (natural, demographic, and business/industrial), international affairs, and Defense management procedures.

In the 1967/68 curriculum, a decision was made to continue the use of IBM's Business Management Simulation which had been used previously in a batch-processing mode. This simulation met the two criteria; that is, it complemented the curriculum and used automatic data processing. SIMCOM had originally hoped to time-share the model in order that the students could use remote terminals in asking "what-if" type questions prior to final decision inputs for each decision period. That goal could not be accomplished for the fall of 1967; but it has been achieved now, and participants are currently engaged in the activity at ICAF. The simulation began on 21 October and will run through 13 November, decision periods are scheduled no more frequently than every other day.

For the international relations phase of the curriculum, the World Politics Simulation (WPS) was selected. This simulation is an adaption of Professor Harold Guetzkow's Inter-Nation Simulation (INS),[13] prepared by Professor William C. Coplin at Wayne State University under contract for the State Department. SIMCOM modified WPS, with the help of Dr. Coplin, and introduced it into the curriculum during January 1968.* Again, WPS met the criteria of curriculum orientation and use of computer programs to process data relevant to the simulation.

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[12] Captain James E. Forrest, USN, ADPS (succeeded by Colonel Lee S. Baumann, USAF) and Colonel W. T. Minor, USAF, Simulation.

[13] Guetzkow, Harold, Simulation in Social Sciences, Chapter 7 (Prentice-Hall, Inc.: Englewood Cliffs, N. J., 1962).

*The SIMCOM modification of WPS was renamed, WPS II.

For the DOD portion of the curriculum, TEMPER (Technological, Economic, Military, and Political Evaluation Routine) was carried out, for the final time, in May 1968. While TEMPER made some contribution to the curriculum and certainly used automatic data processing, its alignment with course content was meager and its use of the computer too rigid, leaving little opportunity for the participants to make effective decisions during the TEMPER runs. Therefore, a trial run with 20 students and faculty members was made, concomitantly with the TEMPER runs, using the Program Management Simulation Exercise (PMSE) developed by management consultants Peat, Marwick, and Livingston for the Defense Weapon Systems Management Center.[14] The PMSE exercise was enthusiastically received by the participants and faculty. It has therefore replaced TEMPER in the curriculum and, after receiving SIMCOM modifications, has been renamed the Defense Management Simulation (DMS).

TO TIME-SHARE OR NOT TO TIME-SHARE

Prior to the establishment of SIMCOM, the accepted idea at ICAF was to install a computer. Fortuitously, in early 1967, the long-awaited time-shared systems were becoming reality. More importantly, they were coming into existence as workable, effective devices and "in a competitive environment." As such; they seemed a viable alternative to computer installation, an alternative promptly explored by SIMCOM and accepted. Major considerations in this decision were cost, versatility, and reliability.

It was obvious that reliability would be an important considera-tion in all simulations at ICAF. Scheduling is a key factor in the ICAF curriculum. There were schedules during the WPS II-68 simulation that allowed only one and a half hours for the input/output routines between game decision periods. The coded input and printed output required one hour and twenty minutes--leaving little time for computer faults. Through time-sharing, SIMCOM solved this problem by providing back-up capability with other computers and gained reliability through redundancy.

Multiple time-shared systems also provided more versatility, and the cost is less than one percent (1%) per year of the original estimates for installing one average computer at ICAF.[15]

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[14] DWSMC is located at Wright-Patterson Air Force Base and operated under the Office of the Secretary of Defense. Its purpose is to train officers as managers (Project managers) of weapon systems under development.

[15] Original estimates for a computer were $2.5 million. Estimates for software, environmental modifications, and personnel were an additional $3 million. SIMCOM leases time from several different time-shared systems for less than $0.1 million per year.

Time-sharing from commercial systems in a competitive environment has assured SIMCOM of the latest reliable state-of-the-art hardware and software versatility for any requirements extant.[16]

MODIFYING BATCH[17] SIMULATIONS TO TIME-SHARED SYSTEMS

The simulations selected for use in the ICAF curriculum were "on the shelf" (that is, in existence and operational when SIMCOM was organized. The problem to be solved was that of adapting them to the time-shared systems available to ICAF. In order to illustrate this type of problem, some of the procedures used in adapting the WPS will be illustrated.

In selecting the World Politics Simulation (WPS) for inclusion in the ICAF curriculum, a primary consideration was that the model be readily adaptable to ICAF's need. Thus, while minor modifications and elaborations were made, the basic structure of the model was retained.

Of course, the more complete programing of the basic model to operate in a time-shared mode represented a fairly important change. It made feed-back more rapid and gave the simulation greater continuity. For example, when armed conflict broke out between two or more nations, it was possible through time-sharing to have the results of the conflict back to the participants almost immediately.

Another fairly important change arose from the decision to assign the names of actual nations to the teams. Prior to the ICAF runs, fictitious names had been assigned to the nation-teams. The attributes (variables and parameters) characterizing simulated nations were more or less prototypic of general nation types; e.g., economically highly developed democracy, economically underdeveloped autocracy, or economically developed or underdeveloped totalitarian dictatorships. In assigning the names of actual nations to these teams, it was logical to alter and adjust the variables and parameters characterizing them so as to correspond more closely to the attributes of the referent nations and/or to produce results more consonant with the actual operations of these nations.

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[16]Time-shared systems include GE, IBM, and SDS.

[17]"Batch" processing means running one set of programs at a time. Turn-around time may be a few minutes or a few days, usually several hours at best.

Because of the primary concern for illuminating the problems of formulation and implementation of national policy, some aspects of the model were made more highly structured so as to emphasize governmental decisionmaking. For example, in WPS II each team represented the government of a nation and as such had veto power over any trade arrangement made with another nation. The team members did not, however, negotiate specific trades as they had done in previous versions of WPS. They simply accepted or rejected proposed trades provided by Control. In making this change, the assumption was that actual trades are negotiated by the business and economic leaders within a nation and not by people in the upper policymaking levels of government. To require participants to conduct such negotiations would have been to divert them from those functions of policymaking and execution with which they should have been most concerned.

As with almost any simulation, the WPS II model will always be subject to revision and improvement. There are current efforts in this process; by the time it is used again (February 1969) substantial improvements are anticipated. Of course, it is not suggested that this will be a final product, but it should be a positive step in the process of building an ever more useful simulation.

COMPUTER CONSIDERATIONS INVOLVED IN THE IMPLEMENTATION OF WPS II AT ICAF

Examples of some of the problems involved in converting the WPS computer programs to operate on another system may be instructive.

WPS was originally programed in the "GE Time-Sharing FORTRAN" for the GE 265 system (this language is a version of FORTRAN II). In order to run WPS for four simultaneous "games " within severe time constraints, it was necessary to find a time-sharing facility possessing rapid response and a capacity for large disk files with quick access capability. The GE 605 system at Missile and Space Division, Valley Forge, Pennsylvania, was chosen.

The first step was to convert the original programs to the Valley Forge version of FORTRAN IV. Even though the FORTRAN language comes closer than many other languages to being truly machine-independent, the differences between these two time-sharing versions of the FORTRAN language were surprising and troublesome. Detailed actions taken by SIMCOM were as follows:

a. Statement labels formerly alpha-numeric had to be changed to pure numeric.

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b. The earlier version permitted the programer to designate any alpha character, as the initial character of any variable, representing either an integer or real number. All variables had to be searched out and made to conform to FORTRAN IV conventions.

c. In the earlier version, the arithmetic "IF" statement did not require three statement numbers; for FORTRAN IV, these had to be assigned and accounted for.

d. Since the 605 compiler would not accept "non-operating statements", all such statements left over from the revision process had to be located and deleted.

e. All input/output statements, the identification of continuation lines and comments, and format statements using continuation lines had to be rewritten.

In view of the above, the simplest course of action was to recode the programs entirely. Further, it was decided to take advantage of the fast response of a time-sharing system to provide immediate results when a "war" occurred, replacing the hand-calculation previously used.

The data base for each nation was quite large, about 1800 computer words (four characters per word). Due to a restriction on the size of individual disc-files in the original system, each nation's data base had been divided into two separate files. This proved to be inefficient and too slow.

Since the 605 system could accommodate larger individual disc-files, each nation's data base was transferred from the 265 disc onto punched paper tape--two tapes for each nation. When an attempt was made to read these tapes into the 605 system, it was discovered that they were completely unacceptable and unreadable, since they were "non-parity" and the 605 system required "parity". The only solution was to write a special program to read in the original tapes and punch out tapes converted to the correct form. This was done on a PDP-8 computer. The problem of joining up each nation's pair of tapes into one file was resolved, but not without difficulty. The listings of each nation's data base had to be laboriously checked and proofed and, as might be expected, corrected.

SIMCOM considers these problems that may reasonably be expected when programs and files are transferred between different systems. Further, the conversion effort was complicated by the fact that the 605 system was relatively new at the time; a certain number of problems can normally be expected under such circumstances.

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In order to produce teletype-printed outputs within the short time allowed, it was necessary to streamline the principal report. The revised program realized a 50 to 60 percent saving in print time. Also, a number of safety features were developed, such as having the computer specify the exact input data required at any specific time, the capability of correcting input data after transmittal to the computer, and a confirmation check of the specific game being run in order to maintain file integrity.

Experience with time-sharing at ICAF has taught one essential fact: If system response must be received within a relatively short period of time, as was the case for the four simultaneous WPS II games, a back-up system is mandatory. For WPS II, this was provided by the GE facility at Syracuse, New York, where the programs and data-base files were loaded on-site prior to the running of the simulation. Following the run of each decision period, the updated files for all games were immediately transferred to punched paper tape, which was then used to create new files at the Syracuse facility. This bit of prudence paid off handsomely. At one point during the run of the second decision period, there were over 50 users on-line in the Valley Forge system at the same time. Three times, a weird BIT-configuration received from an unidentifiable remote terminal caused the system to go down, each time for about fifteen minutes. Each ICAF terminal operator shifted to the Syracuse system as he was affected, and, with a minimum of rerunning, completed the job. None of the simulation participants knew of the difficulty. While the original motivators which influenced SIMCOM's decision for time-sharing were economy, versatility, and reliability serendipity has played its part in this two-year venture.

During this second year, all simulations will allow the participants the prerogative of "communicating" with the model prior to final decisions required at the end of each game period. This may become the most valuable contribution to the learning process, since interaction with the model-- that is, adjusting variable values for a given state of the model--can provide learning insights not otherwise produced. While this is not true simulation interaction,[18] it is an effort in that direction. With this type of man/machine interface, it will become possible to have more continuous simulation interaction, a SIMCOM goal.

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[18] Harvey A. Shapiro (Carnegie-Mellon University) defines interactive versus non-interactive as follows: "In current terminology, interactive and non-interactive describe the mode of play between a computer and a human. Interactive implies the ability to communicate with the computer at the time that the actual simulation is being processed."

PROBLEMS ENCOUNTERED AFTER MODEL MODIFICATION TO TIME-SHARING

Solving the problems of model modification for time-sharing was, at times, the least of SIMCOM's worries. In first-year attempts to introduce the students to time-sharing and motivate them to use the remote terminals, efforts were considerably less than successful. Time sharing was introduced by an instructor to groups of about 15 students. After a non-technical explanation of time sharing, the terminal operation was demonstrated using a very simple "check list." Following the second or third demonstration, students were asked to try the terminal. Not only was there great reluctance, but some students categorically refused "to demonstrate their lack of knowledge before their peers." That was the key to the problem.

This year, SIMCOM has installed 15 terminals throughout the ICAF building. There is one in each of the 12 seminar rooms.[19] A COMPUTER TIME-SHARING USER'S MANUAL was designed for non-technical explanation of the time-shared systems available at ICAF; the manual contains a separate check list of operations for each system. A 15 minute briefing on the manual was given to all students prior to distribution of the manuals. One short paragraph in the foreword was emphasized:

> This manual has been prepared to assist you in making
> use of the time-sharing computer facilities available
> at the Industrial College....Try it! You cannot hurt
> the equipment or the computer. If you make a mistake,
> the worst that can happen is that you will be disconnect-
> ed. Simply re-dial the number and start over.[20]

For the complete novice, the TUTOR[21] series was suggested. For the sophisticated programer, the manual lists programs available in each system. These include business/accounting, mathematical/statistical,

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[19]The 180 students are divided into 12 fifteen-man groups. Each group has a specific seminar room assigned as its base for group activities.

[20]Computer Time-Sharing User's Manual, SIMCOM, ICAF, 1968.

[21]TUTOR is the Philco-Ford series of CAI on BASIC, developed for General Electric.

and scientific/engineering programs in BASIC,[22] FORTRAN IV,[23] and ALGOL.[24] One of the prime advantages of time-shared systems is the amount of productive software available with each system. At no extra cost, SIMCOM has available for students and faculty several hundred published software programs, which result in significant savings in time and dollars compared with the requirement of writing one's own program(s).

In addition to BASIC, FORTRAN, and ALGOL, SIMCOM plans to add TINT, CAL, HELP, DDT, LISP, QED, SNOBOL, SYMBOLIC,[25] and a CAI compiler called LYRIC.[26]

The acceptance by ICAF students of the user's manual, and of working at a terminal with no observers or instructors, has been outstanding. Students previously unwilling to operate a terminal in front of their peers are using the system in the new "unassisted" environment to such a degree that SIMCOM budgets have required adjustment to provide funds for unanticipated time-sharing costs.

Early problems encountered with the time-sharing systems included busy signals due to insufficient lines or an inadequate communications executive in the time-shared system. Down time on main systems is seldom a problem with commercial systems, even short down times, however, reduce system utility and user motivations.

Response times are too slow during peak usage periods on both government and commercial systems. SIMCOM's judgment is that a delay of more than 10 seconds is unacceptable. A maximum delay of 3 seconds is a reasonable goal. Aborts during on-line programing (regardless of the reason) sometimes require reprograming all the way back to the system level. Better executive routines are needed to "save" programs automatically, rather than forcing one back to system level. Line problems, while not primarily a part of the time-shared system, are certainly a part of the system as far as the user is concerned and should be improved to reduce to near zero the parity difficulties which all too frequently make communication between user and system impossible.

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[22]Beginners All-Purpose Symbolic Instruction Code, developed at Dartmouth College by Professor John H. Kemeny.

[23]FORmula TRANslation, Fourth generation.

[24]ALGOrithmic Language (some authors: ALGebraic Oriented Language).

[25]The new capabilities will be provided by DIAL DATA, a commercial time-sharing company with operations in the Boston and Washington areas. (TINT is time-shared JOVIAL, scheduled to be available on Rome Air Development Center's G.E. 635/645.)

[26]A compiler to be used as a pre-FORTRAN compiler, developed by Doctors Leonard and Gloria Silvern, University of California, Los Angeles.

FUTURE TIME-SHARING IMPROVEMENTS DESIRED

When one considers better time-sharing for the future, Professor Tom Schelling's[27] rhetorical question "How does one make a list of all the things he can't think of?" takes on pointed significance. One way to achieve such a list is to make a beginning. The following relevancies, little considered ten years ago, are good starting points.

Competition will probably drive the user cost to acceptable levels. So many new time-sharing companies are coming into existence, it is impossible to stay abreast of weekly numbers and their respective capabilities. This should result in improved service and reasonable cost. No doubt, companies poorly managed will fall by the wayside.

In addition to elimination of call-up delays and processing delays, more "push-button" type software must be developed for management-type users. Communications between consoles must be improved so that simulations can be monitored and controlled by the simulation's Control Team. That is, Control must maintain cognizance of all inter-team console messages, have the capability to deny messages prior to read-out by the recipient, and have the capability to maintain two-way communications with any or all teams at all times.

Consoles should be designed for at least three functions, each with variable capability. For example, the keyboard should offer the on-line programer full capability and at the same time provide the novice with "push-button" type operation. There should be visual display, with the remote console using voice grade circuits with up to 2400 Baud[28] speed. The display should be color capable, with the color generator an integral part of the console. The third capability for tomorrow's console is hard-copy generation of data display. The printout capability should include total or selective hard copy, at the discretion of the user. It should not interfere with continuous use of the CRT.

Where ICAF has acquired multiple time-shared systems to provide reliability through redundancy, the successful commercial time-sharing companies of the future should provide this type of reliability as a part of their standard service.

Software for the user should be provided by the time-shared system in every increasing quantity, quality, and versatility. Certainly it

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[27] Professor Thomas C. Schelling, Harvard Center for International Affairs, Consultant/Director for "Cold War Games" conducted during Minor's tour as Chief, Cold War Division, Joint War Games Agency, 1965/1966.

[28] Baud is an expression of BIT rate transmission. The 2400 Baud rate will fill a CRT in about 2 seconds.

should include many computer languages and programs in math, statistics, accounting, scientific applications, and engineering routines. In addition, the time-shared systems should provide complete simulation packages with self-instructional capabilities. There should also be large and versatile data bases to meet the needs of users from diverse disciplines. Eventually, the entire Library of Congress should be at the "finger tips" of the student, the researcher, and the scholar.

The amount of the central processing unit (CPU or "core") available to each user today is frequently too small. Time-shared systems of the future will probably solve this problem in a modular design which will be controlled by the system's executive routine in a manner not requiring the attention of the user, thus giving the illusion of unlimited capacity--analogous to the illusion of today's user that he is the only user on the system.

This paper has identified only a few of the problems associated with current time-shared systems. It does not claim a listing of all needed improvements. Perhaps, however, it may motivate capable specialists to attack some of the relevancies for improved time-sharing, especially where simulation as an educational tool is concerned.

SECTION III

HISTORY OF ACTIVITIES OF THE

SIMULATION AND COMPUTER DIRECTORATE

1968 - 1969

Originally Prepared as Appendix VI
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1969.

DIRECTORATE FOR SIMULATION AND COMPUTERS

I. GENERAL

The Simulation and Computer Directorate (SIMCOM) was established on 22 January 1968 for the purpose of providing simulation and computer support for the College. The Directorate is responsible to the Deputy Commandant for the planning, development, and supervision of simulation and ADP programs and for the training of faculty members in the use of these techniques. The Directorate continuously reviews and analyzes simulations currently in the curriculum and investigates others as possible substitutes for, or complements to, existing exercises. To keep abreast of developments in the field of simulation and computers, SIMCOM maintains liaison with the academic community, Government agencies, other military schools, and private organizations active in the field. The Director serves as a permanent member of the ICAF Faculty Board.

II. PERSONNEL

As a result of the FY 1969 Manpower Survey, the Directorate was authorized additional line positions as follows: one Special Project Officer (O-5), one Administrative Officer (GS-11), and one Secretary/Steno (GS-6). During the past year, the latter two positions were filled with a GS-9 and a GS-6, respectively. A request has been submitted for manning of the O-5 Special Simulation Project Officer. For FY 1970, the Directorate has been authorized two additional Special Project Officers (O-5's). A Simulation Technical Adviser (GS-15) and an additional Computer Programmer (GS-12) have been authorized for planning purposes. With authorization and manning of the latter two positions, SIMCOM will be able to carry out its chartered function with a minimum of outside contracting and consultation.

III. SIMULATION

Resident students participated in three computer-assisted simulations again this year as part of the ICAF core curriculum. Two of these, the Management Decisionmaking Exercise (MDE) and the World Politics Simulation (WPS III), were substantially modified and improved versions of simulations used last year. The third, the Defense Management Simulation (DMS) was new to the curriculum and replaced

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the TEMPER exercise used last year. A major innovation in all of our simulations has been the inclusion of a query capability which allows the students to interrogate the models via time-share terminals. This "what if" capability enables the students to immerse themselves more readily and more fully in the simulated environment by allowing them to explore and evaluate the likely consequences of various courses of action. We have also sought to enhance the realism of our simulations through the development of sounder data bases, richer scenarios, and closer integration with other facets of the ICAF curriculum. New and more detailed instructional materials have been prepared for both those participating and administering the exercises. All of these items have added substantially to the quality and effectiveness of the College's simulation activities. Perhaps even more importantly, this year's exercises have benefited from widespread and enthusiastic faculty participation. Not only has the resident faculty been responsible for the effective administration of all three of our simulations, they have also led thorough and imaginative post-game evaluations and critiques which have contributed significantly to the learning value of the exercises.

The Management Decisionmaking Exercise (MDE)

The Management Decisionmaking Exercise was conducted as a part of Course 430--Management of Industrial Resources. The exercise is a specially adapted, time-shared version of the IBM Management Decisionmaking Laboratory. During the simulation, student teams assumed the roles of executive managers of a competitive business firm. Operating in an environment that highlighted and summarized important aspects of their previous instruction (e.g., marketing, research and development, and production in a competitive environment), the students confronted and acted upon a variety of typical business management problems. The primary purpose of the exercise was to provide the student with a synthetic but realistic experience that would demonstrate the organization, planning, and analysis required for sound management in a dynamic business environment. A secondary purpose was to allow the student to become more familiar with the use of computers, both as an aid in decisionmaking and as a tool in management training. The exercise also served to foster a better understanding of simulation and modelling techniques.

World Politics Simulation (WPS III)

The second simulation exercise in the ICAF curriculum, the World Politics Simulation III, was conducted as part of Course 450-- National Economic Problems and Policies. It was designed to highlight and complement lessons learned not only in Course 450 but also in earlier courses, most particularly Courses 410 and 440. In this simulation, student teams acted as the national political leadership

of one of six different nations. In these roles, they were called upon to develop and implement policies involving political, diplomatic, economic, and military strategy. The primary purpose of the exercise was to expose the students in a fairly dramatic way to some of the problems and pressures involved in the formulation and execution of foreign and domestic policy at the highest levels of government. As in the Management Decisionmaking Exercise, a secondary purpose of the simulation was to afford the students further familiarity with the variety and uses of simulation and gaming.

Defense Management Simulation (DMS)

The third and final simulation used in this year's curriculum was the Defense Management Simulation. It was conducted during Course 460--Management in the Department of Defense. This simulation was a modified version of an exercise developed by Peat, Marwick, and Livingston under the name of Program Management Simulation Exercise (PMSE) for use at the Defense Weapon Systems Management Center (DWSMC). It replaced the Technological, Economic, Military, Political Evaluation Routine (TEMPER) used in previous years. In DMS, student teams act as DOD program managers responsible for the development and procurement of a new weapon system. During the course of the exercise, students had an opportunity to cope with many of the problems typically encountered during the major phases in the life-cycle of a weapon system (e.g., the management problems involved in attempting to control cost, performance, and schedule). The primary purpose of this simulation was to give the students some practical familiarity with significant features of current DOD management practice emphasized in the ICAF curriculum. Again, a secondary purpose was to provide the students further experience with simulation and simulation methods.

Other Simulations

While the above simulations were the only simulations actually conducted as part of the regular ICAF curriculum this past year, SIMCOM is responsible for reviewing developments in the field of simulation and computers with an eye toward improving and/or enhancing the quality of ICAF's simulation offerings. Consonant with this, SIMCOM advised and supported a thorough investigation of the Aerospace Business Environment Simulation (ABES) undertaken by a student research committee. This game was originally designed for use by Lockheed in their management training program. It places the participants in executive management roles of a highly competitive, defense related industry. On the basis of their research, the student committee recommended that ABES be considered for possible inclusion in the curriculum. Their recommendation is currently under consideration.

One of the continuing objectives of SIMCOM is to provide the College with as broad and as flexible a simulation program as possible Pursuant to this, SIMCOM has sought to develop a library of simulations which are fully operational and available for use at ICAF in either regular or refresher instruction. In addition to those simulations already mentioned, our library now includes the Wharton Business Game, the Inter-Nation Simulation (INS), TEMPER, Dromedary/Revelation, and several smaller gaming exercises.

Analysis and Development

SIMCOM's responsibilities do not, of course, cease once a simulation is incorporated into the curriculum of our library. Firstly, it seeks to constantly improve and refine the models and procedures used in the current simulation exercises. This involves a program of fairly detailed and systematic analysis and evaluation of all ICAF simulations. Secondly, SIMCOM monitors new developments in the field of simulation which might be added to or substituted for existing ones and which promise to enhance the quality of the ICAF program.

Drawing upon both our in-house experience and our contacts with others active in the field, the Directorate undertook a major research project this past year to explore the feasibility of developing a year-end summarizing simulation (YES) for ICAF's curriculum. As part of its investigation, the Directorate solicited and received the advice and counsel of several leading authorities in the field of simulation and gaming. The main conclusion arising from the study was that ICAF's current strategy of incremental development and improvement of existing simulation models allows for more effective utilization of resources and personnel and for greater responsiveness to ICAF's diverse and changing curriculum needs than would be possible with the development of a YES model. Therefore, it has been decided that no attempt will be made at this time to develop a year-end summarizing simulation. Rather, the Directorate will concentrate its efforts on adapting and improving current models to better fit ICAF needs and developing smaller models designed for fairly specific pedagogic purposes.

IV. COMPUTER APPLICATIONS

In its early planning for the development of a simulation and computer capability, the College considered the acquisition of a large-scale computer. However, for reasons of economy, reliability, flexibility, and convenience, the College has come to rely almost exclusively on time-shared and remote computer operations. We have continued to explore the possibilities of establishing an exclusive

computer system in cooperation with other senior Service institutions; but for the present, we have found the extensive capabilities now available through time-sharing and remote operations amply suited to ICAF's needs.

During the past year, the College has installed nine additional teletype terminals bringing its total to 15, one of which is totally portable. This has enabled us to place a terminal in each of ICAF's 12 seminar rooms, while at the same time providing terminals to support the planning and research activities of the Office of Academic Plans and Research and SIMCOM. The placing of terminals in the seminar rooms has greatly facilitated both classroom and individual student use of the diverse computer capabilities provided through the time-shared systems used by the College. The totally portable terminal has allowed students and faculty members to make use of the computer in their own offices or at their own homes. It has also made it possible for ICAF to demonstrate its computerized activities and capabilities almost anywhere.

Through its teletype terminals, the College uses several time-sharing computer systems, which afford highly versatile and reliable service at a relatively modest cost. The College relies primarily on four commercial systems, but also has ready access to the GE645 computer at the U.S. Air Force Rome Air Development Center and the GE 255 located at the '.S. Military Academy. The four commercial systems include: The Information Processing Center (IPC) at Bethesda, Maryland, which uses a GE 265; the International Telecomputer Network (ITN) also at Bethesda but using a GE 635; the General Electric Information Service Division (ISD) at Valley Forge, Pennsylvania, which uses a GE 605; and the IBM Call 360 system in Philadelphia. These systems provide the College with an elaborate library of utility programs and a highly flexible programming capability, allowing the use of BASIC, FORTRAN, ALGOL, and PL/I.

The acquisition of a high-speed data terminal (GE 115) and its auxiliary equipment has given the College a remote batch-processing capability. This has enabled the College to respond to jobs requiring the processing of large quantities of data and high volume output. This new capability has been of crucial importance to the development of several automated programs, two new simulation exercises, and three major student research projects.

Support for the Resident School

In addition to providing computer support for the simulations used in the resident curriculum as discussed above, SIMCOM has provided computer support for resident courses in Automatic Data Processing Systems (Course 503), Quantitative Analysis in Management (Course 504), Mathematics (Course 708), and in Computer Programming (Courses 706

and 704). The Directorate has also provided assistance and advice to both students and faculty of the Resident School on matters related to computer applications, to include student research projects, course development, and student-faculty training. Special programs have also been developed to automate some of the Resident School's administrative procedures (e.g., student group assignments and student office assignments).

Support for the Seminar School

SIMCOM has worked with the Seminar School in developing the capability of demonstrating ICAF's computer activities and capabilities during their Seminar trips. The Directorate is also working with the Seminar School to develop a capability for storing, maintaining, and retrieving information on Seminar participants.

Support for the Correspondence School

Substantial progress has been made during the past year on a continuing project to automate a wide variety of administrative tasks for the Correspondence School. When fully operational, the system will perform record-finding and maintenance functions, inventory control, test grading and recording, and will generate a variety of report statistics. SIMCOM has already developed an automatic labeling system for use by the Correspondence School in handling its high volume of outgoing mail.

Support for Academic Plans and Research

With the development of a remote batch-processing capability, SIMCOM can now provide full computer support for the research and planning activities of the Office of Academic Plans and Research (AP&R). The Directorate has worked with AP&R in developing and improving an information retrieval system which provides background information on students and faculty. This system allows the user to search out and identify persons with experience or expertise in a variety of areas. The possibility of interfacing an optical card reader with one of the College's teletype terminals is currently being explored. If feasible, this would allow rapid in-house processing of the student critique cards using the extensive statistical libraries made available through our time-shared systems. It might also make it possible to maintain historical files which could be easily up-dated and selectively retrieved. All of which would greatly facilitate the research and analysis activities of AP&R.

Support for the Secretariat

Working with the Secretariat, SIMCOM has helped compile and automate a listing of ICAF's alumni and faculty. This has resulted in a College Directory that can be easily up-dated in the future. The Directorate has also developed an automatic labeling system to facilitate mass mailings to alumni.

Support for SIMCOM

In addition to providing support for the other directorates at ICAF, the computer capabilities available through SIMCOM play a vital role in its own internal operations. They allow for the in-house development, adaptation, and/or modification of simulations and provide the analytic capabilities necessary for the evaluation of simulation exercises. The Directorate also foresees the use of automated procedures in fulfilling its responsibility to develop and maintain comprehensive bibliographic and data files on plans, research, operations, and analysis applicable to simulation and automation in the academic community, governmental agencies, other military schools, and private organizations.

V.   COOPERATION WITH OTHER SENIOR SERVICE SCHOOLS

While SIMCOM's efforts are directed toward the support of other ICAF directorates, these efforts have also provided the basis for coope·ation with and assistance to other military schools. As a result of the desire on the part of several senior Service schools to share the benefits of closer cooperation and consultation on matters relating to simulation and computers, an ad hoc committee has been formed to explore the desirability of a consortium (SHARESIMCOM) using common computer and simulation facilities. The Director of SIMCOM serves as the current chairman of this committee.

In addition to the above, SIMCOM has been a regular participant in periodic seminars on "The Use of Computerized Gaming Applications in Military Education" hosted by the DOD Computer Institute. The Directorate also maintains contact with other military schools on an individual basis and has provided assistance and advice to those wanting to develop a simulation and computer capability similar to that of ICAF.

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13. ABSTRACT

   On 22 January 1967 ICAF formed a new directorate (the 5th) for "Simulation and Computer" applications in education. The history of forming this organization is contained in the first section of this publication. The second section deals with current and future uses of time-sharing in educational uses of simulation. The final section contains the history of activities during the most recent academic year, 1968/1969.

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